

## **Radiation Isotope Identification Device (RIIDs)**

### **Field Test and Evaluation Campaign**

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#### **ABSTRACT**

Handheld, backpack, and mobile sensors are elements of the Global Nuclear Detection System for the interdiction and control of illicit radiological and nuclear materials. They are used by the U.S. Department of Homeland Security (DHS) and other government agencies and organizations in various roles for border protection, law enforcement, and nonproliferation monitoring. In order to systematically document the operational performance of the common commercial off-the-shelf portable radiation detection systems, the DHS Domestic Nuclear Detection Office conducted a test and evaluation campaign conducted at the Nevada Test Site from January 18 to February 27, 2006. Named “Anole,” it was the first test of its kind in terms of technical design and test complexities. The Anole test results offer users information for selecting appropriate mission-specific portable radiation detection systems. The campaign also offered manufacturers the opportunity to submit their equipment for independent operationally relevant testing to subsequently improve their detector performance. This paper will present the design, execution, and methodologies of the DHS Anole portable radiation detection system test campaign.

#### **INTRODUCTION**

The U.S. Department of Homeland Security (DHS) Domestic Nuclear Detection Office (DNDO) sponsored testing of handheld, backpack, and mobile sensors at the National Nuclear Security Administration’s NSTec’s Nevada Test Site (NTS) as part of the Portable Systems Testing Program. The goals of the Anole test were to:

- Validate existing concepts of operation to better align concepts with current commercial off-the-shelf and government off-the-shelf radiation detection systems’ capabilities.
- Ascertain the performance envelope for each detector system in each test scenario.
- Enable DNDO to guide state and local users in their selection of detector systems. Findings will help state and local users leverage grants from DHS to focus on acquiring successfully tested equipment for specific radiological or nuclear threats.
- Invite the participation of DNDO federal, state, and local governmental partners and share data, albeit in accordance with partner constraints.
- Influence DNDO system architecture decisions by assessing the effectiveness of existing detector systems and obtaining ground truth for future system studies.
- Help the development of performance specifications and standards, and contribute to building a database of equipment and test results.
- Test and evaluate reachback operations for systems with spectral capability.

The Anole test was the first test of handheld, backpack, and mobile radiation detection systems at NTS. The purpose of this test was to characterize the effectiveness of handheld, mobile, and backpack sensors for use in field-like, yet reproducible, conditions using realistic sources, test objects, and usage scenarios. In addition, lessons learned from this test will be documented and made available to all test teams responsible for future tests<sup>1</sup>.

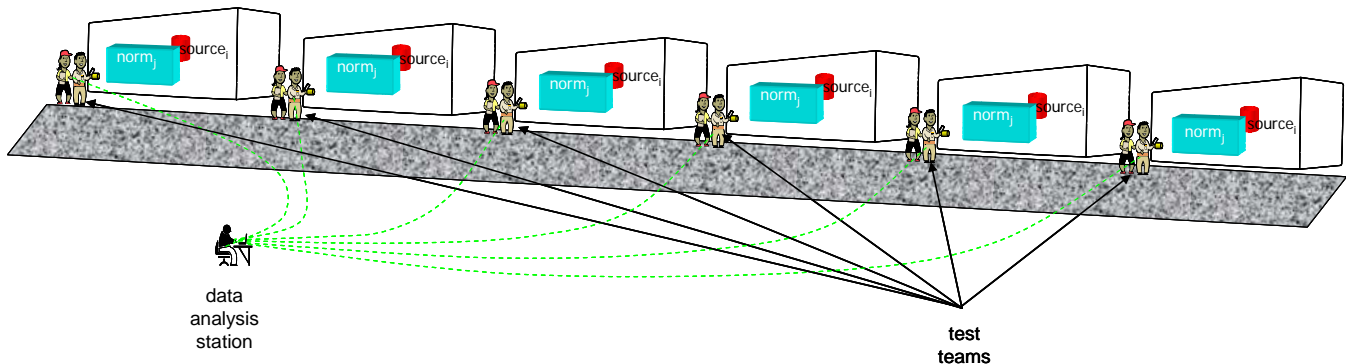
The test program was executed at the NTS, encompassing eight weeks of testing that began in January 2006. Thirty-one instruments were tested, including eleven handheld devices, nine backpacks, and eleven mobile systems. There were 8,377 individual test cases performed. The data were archived in real-time into a permanent database to include all test parameters and scenarios, test data, photo documentation, spectra, notes, and observations. Presented in this report is an analysis of the instruments' ability to distinguish a variety of sources in several different scenarios<sup>2</sup>.

## TEST DESIGN

### TEST SCENARIOS

#### Scenario 1 - Secondary Screening Scenario

The unloaded and loaded truck scenario is based upon the typical U.S. Customs and Border Protection (CBP) protocol<sup>3</sup> for secondary screening of cargo vehicles upon an initial alarm by a portal device. Alternatively, the scenario could correspond to handling a pager alarm during a



**Figure 1 – Scenario 1 - Secondary Screening**

routine traffic stop or screening a limited number of vehicles entering a controlled area. The goal is to establish handheld performance for threat objects in both an otherwise empty truck and a cargo-filled truck. The scenario assumes the vehicle has been halted for further inspection after triggering a screening alarm. Further inspection includes precise location of the alarming event in the vehicle and then identification of the cargo causing the alarm. Protocol is to determine as expediently as possible if the cargo requires further inspection or if it is allowed to continue to its destination. The second part of this scenario was the identification of the alarming event. For this part, a spot on the exterior of the CONEX\* was marked nearest the source position. Each team would then acquire identification data at this point. Assay times varied from individual instrument requirement up to a maximum of 2 minutes. Depending upon the specifics of a particular scenario, the CONEXes may loaded with Naturally Occurring Radioactive Material (NORM).

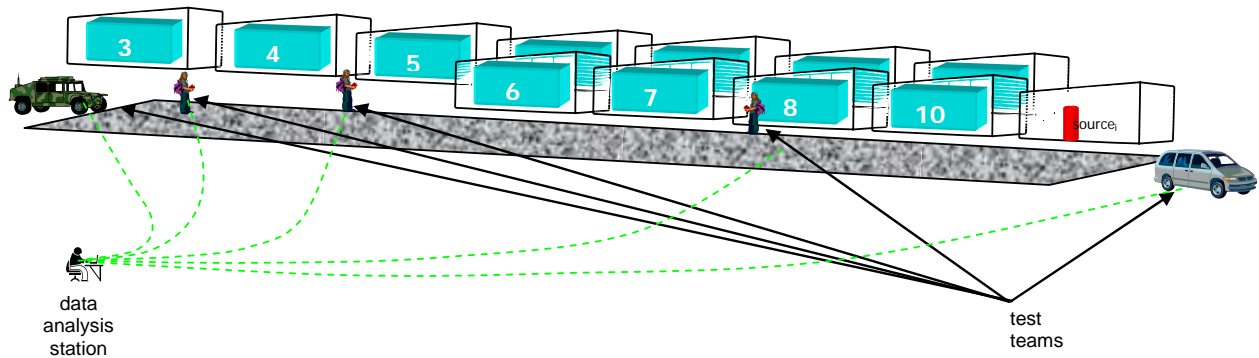
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\* Military Term for Container Express, more commonly known as a containerized cargo or sea-land containers

## Scenario 2 – Wide Area Urban Sweeps

Scenario 2 was based on law enforcement operational scenarios requiring the survey of wide areas prior to a special event or following a threat indication. The scenario utilized a mobile or backpack detection system for clearing a parking lot or open area. The goal was to establish mobile and backpack performance for threat objects considered in this scenario.

The pictorial for this scenario is shown in Figure 2. NORM containing CONEXs were lined up such to create an artificially high fluctuating natural background. A test source was placed in the middle (front to back) and as close to the roadside face as possible of an empty CONEX as shown. It was the objective of the instrument to pick out this source from the background.

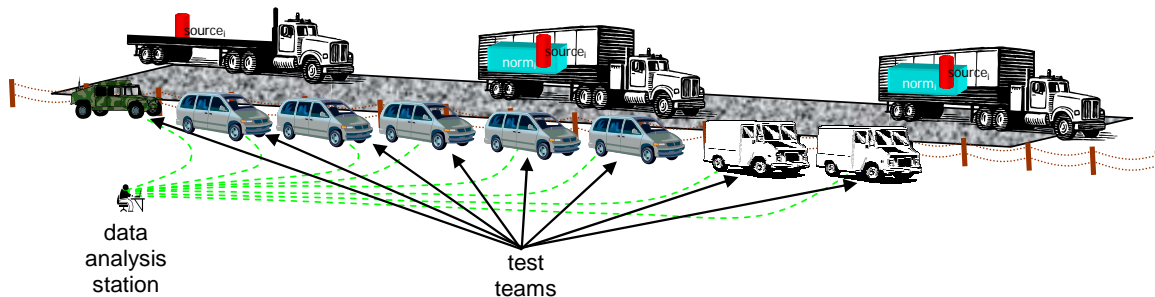


**Figure 2 – Scenario 2 - Wide Area Urban Sweeps**

This scenario was designed to provide a fluctuating high background representative of what might be found in a typical urban venue. When approached from left to right, this fluctuating high background can be observed by instrumentation prior to the test source; from right to left, the source is measured with respect to a normal and uniform background.

## Scenario 3 – Temporary Portals

This scenario is based on the use of mobile detection systems functioning as a temporary cargo screening portal at a port of entry or an interior weigh station. As shown in Figure 3, the mobile systems were lined up along the test track and various NORM and source configurations were driven by at 5 mph and 20 mph. The distance between the CONEX and the mobile unit was approximately 7 ft., which was a limitation of the test track. Data were collected as to alarm and possible identification.



**Figure 3 – Scenario 3 - Temporary Portals.**

CONEX and NORM setup was similar to Scenario 1. The only notable exception was that the source was often in the very front of the CONEX/flatbed to facilitate tying the items to the vehicle. These specifics are documented in the Anole database for each specific configuration setup.

## TEST ARTICLES

Eleven different mobile units, eleven handhelds, and seven types of backpacks were tested during this campaign. Figure 4 shows a sampling of this instrumentation. The mobile instrumentation (top of Figure 4) ranged from large panel vans to units the size of a jeep. A sampling of handheld units is shown in the bottom left and backpack on the right.



**Figure 4 - Test Articles: Mobiles, Handhelds, and Backpacks**

## SOURCE MATERIAL

Source materials were chosen to establish performance relative to select threat objects and typical sources found in the stream of commerce. Sources were often combined to test against specific masking or shielding scenarios. For example, medical, industrial, and SNM sources were often placed in and around NORM material to test the instruments ability to discriminate between the two sources. Examples of these sources are:

- Medical sources
  - $^{131}\text{I}$ ,  $^{99\text{m}}\text{Tc}$
- Industrial Sources
  - $^{241}\text{Am}$ ,  $^{60}\text{Co}$ ,  $^{137}\text{Cs}/\text{AmBe}$ ,  $^{192}\text{Ir}$
- Special Nuclear Material (SNM)
  - HEU, Pu, DU
- Naturally Occurring Radioactive Material (NORM)
  - Cat litter, roofing tiles, fertilizer

## QUALITY ASSURANCE

There were several aspects of quality assurance and quality control that were addressed to assure data integrity. All instrumentation was accepted and tested using American National Standards Institute (ANSI) criteria<sup>4,5,6</sup>. All operators, instrumentation and data collectors were trained, tested, and certified against written procedures to assure minimal performance and consistent level of understanding.

An HPGe spectrum was collected for each unique configuration. Not only was this used to assure configuration control and documentation, but it also served as a comparison for the limiting performance of any of the test articles. Daily background measurements were also obtained with the same HPGe system to document ambient background and its possible fluctuations.

Along with database control of testing and configurations, photo-documentation was obtained on testing and on all unique configurations (see source configuration for additional details).

Quality Control (QC) engineers performed a statistical review of acquired data. These engineers selected a few representative cases and tracked the data from the point of raw data collection in the field all the way through the final report to assure data integrity during collection, recording, and reduction.

The database contains numerous QC checks to prevent erroneous data entry, such as drop-down menus to limit possible input to only known values. The database also performed several logical checks to assure accurate raw data input. Where possible (source, NORM, configuration, instrument, operator identification, etc) information was input via bar code to assure accurate data input. All configurations independently verified by multiple personnel against a pre-written schedule. In most cases, data was scrutinized for consistency (e.g., All operators entered the appropriate speed) prior to the commencement of the next test.

## SOURCE CONFIGURATIONS

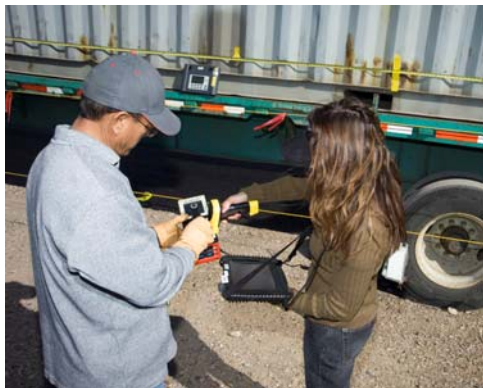
Configurations were selected to establish performance relative to select cargo configurations found in the stream of commerce. Configuration control was maintained by test scientists using the database controls described above, photodocumentation (Figure 5), and required the collaboration of multiple test scientists. The specific test scenarios are described later in this paper, There were 51 test configurations for scenario 1, 56 for scenario 2, and 91 for scenario 3.

Variation in the configurations included differing sources, differing source position for location scenarios, differing source/masks combinations (e.g., Pu with NORM), different shielding combinations (e.g., U surrounded by 1" steel), speed for mobile and portal testing, and detector-to-source distance.



**Figure 5 - Example of Configuration Photo-Documentation Showing Bar Code Data Entry of Source Information.**

## DATA COLLECTION



**Figure 6 – Bar-code scanning of a Handheld System during Typical Data Recording**

Data were recorded in near real-time with the use of dedicated portable tablet computers and tablet operators. The data collection software employed drop-down menus and fill out tables to allow for quicker, more accurate, and more consistent recording of data (Figure 6). Bar code readers were used for identification of test case, instrument, and operator to speed the process and minimize input errors.

Tablet operators and instrument operators were required to verbally verify all data prior to submission. The data was then immediately downloaded via WiFi link where software used a set of rules to check on data integrity and accuracy prior to allowing the operator to continue.

Test case configuration data were also input using a tablet computer. Upon completing the setup of a specific test case, the test coordinator would choose the predetermined test case identification and enter the data associated with NORM, CONEX, source, source position, data documentation photos,



and “ground truth” HPGe spectra. Instrument operators would complete their data acquisition through a series of questions and confirmatory read-backs of information. The tablet operator would then enter the data (see Figure 5).

### ***SCENARIO 1 - SECONDARY SCREENING SCENARIO***

Figure 7 and Figure 8 are photographs of actual testing. Figure 7 shows handheld testing, and shows testing of mobile units. Note the instrument operator for each instrument and the data collectors. Figure 7 also shows the tape measure attached to the outside of the CONEX for uniformity of location measurements.

Vehicle and pedestrian speeds were not a recorded parameter. For identification scenarios, the instrument was located as close as possible to the X on the side of the CONEX. For locate scenarios, operators were allowed to move back and forth until the most likely location of the source was determined.



**Figure 7 – Handheld Testing**

For the location portion of this scenario, operators and data collectors approached the specific CONEX, noting distance of the first alarm event, alarm type, and then the precise localization of the maximum alarm level. The team would then move to the next test case in the configuration,



**Figure 8 - Mobile Unit Testing During Scenario 1**

repeating the same procedures. After all teams completed a cycle, the locations of the test sources were changed to preclude operator knowledge of the source location within the CONEX. This cycle was completed until three successes (up to a maximum of five attempts) were obtained for each test case and each instrument. Up to six test cases per configuration were analyzed.

### ***SCENARIO 2 – WIDE AREA URBAN SWEEPS***

Mobile units were driven by at several combinations of speeds and distances from the line of CONEXs (Figure 9). Backpacks were tested at normal walking speeds and walking distance from the CONEX, as shown in Figure 10.



**Figure 9 – Mobile Testing for Scenario 2**



**Figure 10 – Scenario 2 Backpack Testing**

As previously mentioned, testing was done from both directions, such that the instrumentation saw the high fluctuating background prior to the source coming into view and also from the null or clean background where the fluctuating background of NORMs did not enter the instrumentation's field of view prior to the source.

As the NORM configuration did not change, test cases are defined by the source, the direction of travel, speed, distance (feet), and the instrumentation tested. See "Event Design Plan for Portable Nuclear Detection Systems," DHS Document Number 100180v3.00, dated January 13, 2006, for design criteria specifics.

### ***SCENARIO 3 – TEMPORARY PORTALS***

As shown in Figure 11 the mobile systems were lined up along the test track and various NORM and source configurations were driven by at 5 mph and 20 mph. The distance between the CONEX and the mobile unit was approximately 7 ft., which was a limitation of the test track. Data were collected as to alarm and possible identification.



**Figure 11 – Scenario 3: Temporary Portals.**

This scenario is based on the use of mobile detection systems functioning as a temporary cargo screening portal at a port of entry or an interior weigh station.

A representative selection of backpack and handheld units was also tested as temporary pedestrian portals. In these cases, a source was hand-carried or pulled with a cart (for heavier drums such as the SNM containers) at normal walking speeds (i.e., 3 mph) through the test track. An example of the lineup of instruments is shown in Figure 4.

The test cases are defined by NORM, source, vehicle or pedestrian, and speed. See "Event Design Plan for Portable Nuclear Detection Systems," DHS Document Number 100180v3.00, dated January 13, 2006, for design criteria specifics.

CONEX and NORM setup was similar to Scenario 1. The only notable exception was that the source was often in the very front of the CONEX/flatbed to facilitate tying the items to the vehicle. These specifics are documented in the Anole database for each specific configuration setup.

## **REACHBACK**

Reachback is the process by which information from the result of a field measurement is transferred to a reachback center where it can be further analyzed by leading subject matter experts. This is performed in near real-time and used when field results are indeterminate. The ability to readily transmit and analyze the assay results for this instrumentation is of significant consequence and was tested in the Anole campaign.

For the Anole test, gamma spectra were downloaded from those instruments capable of storing spectra. Due to the multiple vendors and detection system models, the resulting file formats and procedures for downloading the data were very diverse.

The diversity of spectra, required hardware, procedures, proprietary software, and format emphasizes the need in specifying a common format for all Reachback instrumentation.

## **CONCLUSIONS**

The Anole test quantified and documented the following results:

- Conclusions should focus on what the successful design and execution of a complex test campaign that evaluated a broad range and large number of systems.
- Report provided to federal, state, and local emergency responders (available on the Responder Knowledge Base web site to qualified individuals).
- Participating vendors received summary of performance of their individual system to aid system improvement.
- Handheld results used to guide development of performance specification of next generation handheld radiation detection systems.

When choosing instruments for radiation detection, the Anole test campaign has demonstrated that the instruments' primary use needs to be well defined. While most instruments perform all tasks, the data clearly demonstrate that they perform best when operated for the purpose for which they were designed. While a handheld unit could be used as a temporary portal device, handhelds never performed as well as the instruments that were designed for that purpose. Likewise, handheld units clearly performed better than the mobile units for the identification of SNM and the discrimination of non-SNM bearing cargos. In summation, it is best to evaluate the need and specific use and then select an instrument that was engineered for that use.

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